SUSTAINING THE PROFESSIONAL GROWTH OF MATHEMATICS TEACHERS

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Teacher professional learning is a complex activity based on the interaction of three sub-systems: the teacher, the school and the learning activity. Such learning evolves over time depending on salient outcomes and teacher value positions, and requires support that is responsive to the teacher's growth. This phenomenon has been observed within a group of teachers tasked with implementing an innovative curriculum. The curriculum involved an unfamiliar pedagogical practice that was designed to accelerate the mathematics learning of low socio-economic status junior secondary students. Based upon the observations, implications are drawn for the types of support needed to enhance teachers' capacity to engage with pedagogical and curricular changes, with the aim of sustained teacher professional growth.

INTRODUCTION

This paper presents an analysis of the professional learning (PL) activities that were provided to support a teacher's professional growth. These PL activities were provided for the teacher as she implemented a curriculum innovation as part of a project titled *Accelerating the Mathematics Learning of Low Socio-Economic Status Junior Secondary Students (XLR8).* The activities were analysed in relation to Nutchey, Grant, Cooper and English's (2015) *interpretation continuum* that characterises teacher curriculum interpretation practices in terms of curriculum structure, sequence, pedagogy, resources, and assessment on a four point scale: Resister, Follower, Questioner, and Improver.

The paper first provides background to the project in relation to literature on teacher PL with respect to mathematics education. Drawing upon semi-structured interview data and classroom observations, the changing needs and teaching practices of a single teacher are described in terms of the support provided as the teacher implemented the XLR8 curriculum. This description shows how the teacher's practices evolved during the curriculum project and discusses the effectiveness of PL support. The effectiveness of the support provided is analysed in terms of the teacher's movement along the interpretation continuum. These results are used to propose conjectures as to the support needed to increase teacher professional growth when implementing a curriculum innovation.

BACKGROUND

The XLR8 project has been designed to develop theory and practice regarding the acceleration of junior secondary students' (Years 8-9) mathematics proficiency in

low-SES schools. The schools identified students to participate whose level of mathematical achievement was assessed to be nominally at a mid-primary school level (Year 4) and who had not been ascertained with learning disabilities. The project has aimed to accelerate students' learning of mathematics such that they are able to enter Year 10 with the requisite knowledge to successfully study mathematics and ultimately enhance their capacity to engage with further study or employment.

To achieve this aim the project adopted design research (Cobb, Jackson & Munoz, 2016) as a basis for proposing, trialling and refining the XLR8 curriculum. The XLR8 curriculum has been designed to carefully explore the structure of mathematical knowledge in a nested, conceptually-focussed sequence (Cooper & Warren, 2011) that builds students' understanding from a low-achievement level to an age-appropriate level. The curriculum has employed a pedagogical framework (referred to as RAMR) which is comprised of teaching cycles of reality, abstraction, mathematics, and reflection learning activities (Cooper, Nutchey & Grant, 2013). The pedagogy is grounded in the students' reality, drawing upon suitable everyday life examples to situate learning. It provides a clear order of abstraction activities that progress through kinaesthetic-iconic-symbolic representations while also connecting to everyday and mathematical language. Mathematical activities build students' fluency with procedures and skills, promote conceptual understanding, and develop and reinforce connections to other mathematical ideas. During reflection, opportunities are made for students to reflect their learning back to reality and to transfer knowledge to new situations and form generalisations. Thus, the XLR8 curriculum has five features (Nutchey et al., 2015): (1) the structure of mathematical knowledge that underpins learning; (2) the conceptual sequence by which the mathematical structure is explored; (3) the RAMR pedagogy used to explore the structured sequence; (4) the resources provided to implement the RAMR pedagogy; and (5) the assessment materials that generate diagnostic, formative, and summative evidence of students' mathematical understanding.

As suggested by Postholm (2012), teachers participated in a range of professional learning activities to support their professional growth as they implemented the XLR8 curriculum: group-based professional learning sessions (e.g., workshops); demonstration and team teaching; personal reflections on practice, reflective conversations following classroom observations, and conversations with colleagues. Although professional learning providers intend to support change in teachers' practices, attitudes and/or beliefs and the learning outcomes of their students (Griffin, 1983), teachers are commonly described as expecting such activities to provide specific, practical ideas directly applicable to their classroom (Cooper, Baturo & Grant, 2006; Fullan & Miles, 1992). However, teachers have a tendency to appropriate their own meaning relating to the content of the professional learning activities (Warford, 2011). This occurs when teachers connect and integrate the activities with their previous experiences as learners and teachers of content, with their tacit and overt perceptions of pedagogy and with educational content and input from researchers,

colleagues, external teachers or other resource persons (the teacher-learning activity interaction in Opfer & Pedder, 2011).

Teachers can take time to develop mastery of the practical elements of curriculum innovations and may not engage fully with the underlying ethos of the curriculum innovation until a comfort level in pedagogical practice has been achieved (Clarke & Hollingsworth, 2002). Teacher professional growth is a gradual and difficult process that necessarily involves effort, anxiety and risk of failure (Guskey, 2002). Thus, teacher PL can fail to bring about change. To some educators, the answer to this is to develop collaborative relationships between researchers and teachers (Ward & Tikinoff, 1982) based on practical resources and activities that provide success (Baturo, Warren & Cooper, 2004). However, other educators argue that success needs PL to challenge teachers, set up cognitive conflict, and apply sustained pressure and support for experimentation (Huberman & Crandall, 1983; Guskey, 2002; Postholm, 2012) through, for example, observation (Zwart, Wubbels, Bergan & Bolhuis, 2009).

APPROACH

Teachers were provided with modules, containing RAMR-based lessons and pre-post-tests, to trial in classrooms. These were accompanied with PL activities which were designed to: (1) meet teachers' needs in terms of mathematical content as well as pedagogy, and engage teachers as partners in decision-making; (2) acknowledge that change takes time and is an interaction of knowledge, beliefs and attitudes, classroom trials and reflection, sustained by observations of positive change; and (3) maintain continued dialogue with teachers and schools through action research approaches to trials (Baturo et al., 2004; Clarke & Hollingsworth, 2002; Cooper et al., 2006). Across 2013-2015, the PL experiences varied in response to school constraints and teacher needs. They included: (1) targeted PL at the start of each year to introduce the XLR8 pedagogy and modules and to experience, hands on, materials and resources for foundational concepts (e.g., place value) usually ignored in the secondary school and in secondary pre-service courses; (2) opportunities throughout the year for teachers to share experiences and explore the next modules; and (3) time before and after lesson observations for teachers and researchers to engage in reflective professional discussion about lesson implementation and student progress (referred to as coaching sessions).

Based upon feedback received from teachers in 2014, the research and PL focus changed at the start of 2015 to emphasise the coaching sessions. Researchers visited schools on a weekly basis at strategically chosen times so that teachers had a free period following their observed class for coaching sessions. These coaching sessions and the lesson observations were run by the same researcher, who was perceived by the teachers to have a practitioner rather than theoretical focus. The coaching sessions were conducted to meet the teacher's needs. Data were gathered by a variety of methods including: (1) field notes during lesson observations and coaching sessions; (2) video recordings of PL discussions; (3) individual semi-structured interviews; (4)

teachers' self-evaluations in terms of Nutchey et al.'s (2015) interpretation continuum; and (5) student responses to tests for each module. The researchers met regularly to share data and discuss classroom experiences. Data gathered from the interpretation continuum were particularly important because central to the underlying theory of XLR8 is that mathematics is a construction influenced by culture, and that the learning of mathematics should be matched to the reality (and culture) of the learner (Cooper et al., 2013). To this end, it was expected that each teacher in the project would critically adapt the presented curriculum so that it was suited to the needs of their students. As briefly described earlier, the interpretation continuum was composed of five subscales that reflect the five features of the curriculum (structure, sequence, pedagogy, resources and assessment). Along each subscale, the teachers could characterise themselves, in discussion with the researchers, as *Resister*, *Follower*, *Questioner* or *Improver* of the curriculum as a measure of the extent they engaged in the adoption and adaption of the XLR8 curriculum. Although it was anticipated that initially teachers might be followers of the XLR8 curriculum, it was hoped that over time that they would move along the continuum to become curriculum improvers.

In this paper the analysis of one teacher, Jackie, is reported upon. Jackie was selected as she is a typical case of the type of teacher for whom the XLR8 project was designed.

RESULTS AND DISCUSSION

Jackie had three years of teaching experience within her school prior to beginning in the XLR8 project, she was a trained mathematics teacher, and she had taught almost exclusively in mathematics classrooms. In the XLR8 project, Jackie taught the same cohort of students for two years of the program (2014 and 2015) and, despite the population transience typical of low-SES schools, her class of students remained relatively constant across the two-year period. Jackie's class could be described as productive; class attendance was high and Jackie's behaviour management processes were well established.

Jackie initially found the whole group PL workshops useful in terms of initial understanding of RAMR pedagogy and explaining the use of resources and practical ways to assist her students to develop mathematical understanding.

> I did do some of those PDs at the beginning of last year, I liked that because I felt like I went in prepared … you can kind of bounce things off each other and have everyone come up with ideas.

Jackie described her teaching style before joining the XLR8 project as relatively didactic and text-book centred.

> … because I've come from a background of very much text book, sit in rows, work out examples and multiple questions to get yourself through so it was really hard at the beginning for me to go from that.

The use of authentic, student-based reality along with inclusion of the Abstraction phase of RAMR prompted Jackie to alter her teaching style to incorporate kinaesthetic activities and hands-on materials.

> Some of the mind, body, hand activities are really hard and it was a stretch to find something to do on certain topics … I felt like is there any point me going into this stuff that doesn't really make sense in my head fully … if I wasn't confident with something then I wasn't going to do it.

These aspects of the XLR8 curriculum were sufficiently foreign to Jackie's usual teaching style that they demanded more of her attention than mathematical structure and the XLR8 sequence during her initial implementation of the curriculum and caused her considerable anxiety.

> In the beginning of the year I was absolutely petrified, mental breakdown, crying in the staffroom … um I'm the type of person who wants everything to be perfect and I don't want to screw anything up, so if I feel like I might screw something up I get really upset.

In 2014, Jackie found class visits in this early part of implementation of the XLR8 curriculum to be difficult and stressful, particularly as they did not have time afterwards for coaching.

> I think with the class visits, like I didn't mind having them done but I just felt like there was no time for me to talk to someone … do you know what I mean, even if it was the day before just to be able to go well this is what I'm thinking of doing.

Jackie persevered with her implementation of the RAMR pedagogy into 2015 as she reported that she could see positive results in student learning and believed that her students enjoyed the activities. As the RAMR pedagogy became a more natural way of working for Jackie she indicated a more general change in her practice.

> It's a big jump but now I have counters in my room and I use them for other classes and sometimes I just use them for an activity, yep this is what we're going to do and come up with my own thing, try to use the materials where I can so it helps me within my other classes, not just my year 8s.

The 2015 changes in support provided meant that an improved researcher-teacher relationship was built, which allowed Jackie to be more relaxed about class visits and provided the additional opportunity for collaborative planning and professional conversations. Also, she felt able to combine the best elements of her previous practice in a way that she felt improved the delivery of the curriculum for her students.

> Just having another person in the room more than anything, I didn't feel judged like I did last year … I just did what I did and asked for feedback. So now I don't feel like I'm going to be judged so yeah that's why I've moved up probably.

Once Jackie achieved a comfort level with the pedagogy, she was able to give more time and attention to developing a better understanding of the structured sequence. This allowed her to recognise and make connections to "what was coming next" and to

better select from her previous resources for use within the Mathematics phase of the RAMR to more effectively consolidate her students' learning.

> I probably deviated … a little bit more than I did the year before, found some of my own stuff as well as using the booklets. Instead of just doing it one way or just doing it the other way, I realised that you need both and if you put both together depending on the topic … if you put both together the kids seems to grasp it more, you feel better about it.

At the end of 2015, Jackie was interviewed and asked to mark on the interpretation continuum her perception of her practice in regard to the five subscales. She was asked to mark what she believed to be her initial practice, *I* (at the beginning of 2014), and her final practice, *F* (at the end of 2015). Her self-evaluations are presented in Table 1. She felt her capacity had moved from resister to follower and finally to questioner and improver. Analysis of interview and classroom observation data gathered throughout the 2-year period led to the identification of shift in practice, labelled *M*. This seemed to occur when Jackie developed confidence in the RAMR pedagogy and so she became more able to consider the other features of the curriculum.

Continuum Sub-scale	Resister	Follower	Questioner	Improver
Structure	I	M	F	
Sequence		I M	F	
Pedagogy		I	M	F
Resources	I		M	F
Assessment	I	M	F	

Table 1: Interpretation profile of Jackie's professional growth.

DISCUSSION AND CONCLUSIONS

Initially, the knowledge that classroom visits were for data gathering purposes caused Jackie stress in regard to whether the pedagogy was being implemented correctly and contributed to an overall perception of being judged rather than supported. The timing of visits did not coincide with gaps in her timetable leaving little time for relationship building or professional support for reflection or planning. Reflective conversations around mathematical structure and sequencing of concepts at this time did little to build Jackie's confidence as they were neither aligned with the focus of her energies nor reduced the cause of her anxiety. Theoretical discussions at this time compounded Jackie's anxiety as they highlighted additional factors to consider rather than addressing her immediate concerns.

In 2015, the changed focus on classroom observations together with professional and collaborative reflective and planning conversations (coaching sessions) allowed for an improved teacher-researcher relationship (cf. Baturo et al., 2004). It provided Jackie with greater ownership of planning decisions (Cooper et al., 2006; Clarke & Hollingsworth, 2002). Alongside the changing support structure, Jackie's developing

facility with changed pedagogical practices enabled her to feel more relaxed with day-to-day curriculum implementation allowing her time and energy to question and improve aspects of her pedagogy and the resources she implemented in her classroom.

Considering Jackie's experience with the implementation of an innovative curriculum program, introductory whole group intensive workshops are important to provide teachers with an initial understanding of the pedagogy and curriculum innovation and immediate practical teaching ideas that they can use with their students. Following initial practice with the pedagogy, classroom visits and observations are necessary to ensure teachers continue to trial the pedagogy but these visits need to be perceived as assistive and not judgemental. Collaborative planning before visits and reflective conversations after visits initially need to focus on the pedagogy and highlight positive aspects of student successes to build teachers' confidence and prompt extended practice with the pedagogy. Once the pedagogy has been mastered, attention to the sequence and structure of the mathematics may be included in professional conversations. Such conversations may help develop sufficient understanding of and fluency with the structure of mathematics, the sequence of the XLR8 curriculum and application of the RAMR pedagogy. With this increased understanding teachers are more likely to recognise the need for additional scaffolding or redirection as lessons progress, to both address students' misunderstandings and support students' acceleration to more complex levels of mathematical reasoning. This paper has illustrated the usefulness of the interpretation continuum as a tool to analyse and explain such changes to a teacher's practice in regard to the various features of a curriculum.

ACKNOWLEDGEMENT

The research reported in this paper is supported by an Australian Research Council Linkage Grant (LP 120200591) awarded to Cooper, English, and Nutchey. Opinions expressed in this paper are those of the authors and not of the Council. The XLR8 researchers would like to acknowledge the contributions made to the project by the participating schools, teachers and students.

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